



China's capacity of hospitals to deal with infectious diseases in the context of climate change



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ABSTRACT

Objectives: Infectious diseases are a major cause of morbidity and mortality in China. The capacity of hospitals to deal with the challenge from emerging and re-emerging infectious diseases due to climate change is of great importance to population health. This study aimed to explore the capacity of hospitals in China to deal with such challenges.

Methods: A cross-sectional questionnaire survey was utilized to gauge information regarding capacity of hospitals to deal with infectious diseases in the context of climate change among 611 clinical professionals whose roles pertained to infectious disease diagnosis, treatment and management in Anhui Province of China. Descriptive analysis and logistic regression analysis were performed on the data.

Results: More than 90% of participants believed climate change would have an adverse influence on population health and infectious disease control in China. Most indicated that their hospitals were well prepared for emerging infectious diseases at present, and they considered that logistical support in hospitals (e.g. administrative and maintenance services) should be strengthened for future capacity building. The majority of participants suggested that effective prevention and control measures, more interdisciplinary collaborations, more funding in rural areas for health care, and improved access to facilities enabling online reporting of infectious diseases, were extremely important strategies in building capacity to curb the population health impact of emerging and re-emerging infectious diseases due to climate change in China.

Conclusions: Clinical professionals recognized that climate change will likely increase the transmission of infectious diseases. Although rural health care and hospitals' logistical support need to be improved, most professionals believed their hospitals to be capable of dealing with emerging diseases. They thought that interdisciplinary and cross-regional collaborations, together with necessary resource support (e.g. improved facilities for rural health care) would be important control strategies.

1. Introduction

Currently there are roughly 7 million cases of reported infectious diseases in China, which result in approximately 17,000 deaths annually (National Health and Family Planning Commission of the PRC, 2016). Previous studies have found the incidence of infectious diseases has been sharply reduced due to great improvements in health care services (Hipgrave, 2011). However, the emergence and re-emergence

of some climate-sensitive diseases, such as malaria, dengue and hemorrhagic fever with renal syndrome (HFRS) have occurred in recent decades in China (Huang et al., 2012; Xiang et al., 2016; Zhang et al., 2010b). Malaria was a serious public health problem during the 1970s with an incidence of approximately 2800 per 100,000 population (Yin et al., 2014). In 2001, the incidence was only 2 per 100,000 with about 20,000 cases reported (Yin et al., 2014). However, malaria cases in China increased to 64,178 in 2006 (Zhou et al., 2007). Moreover, no

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dengue cases were reported prior to 1977, but frequent outbreaks have occurred during the last few decades in China (Lai et al., 2015). HFRS, a serious zoonotic disease caused by hantaviruses, can be transmitted to humans by contact with infected rodents or their excreta (Hansen et al., 2015). The disease is frequently reported in China where roughly 90% of the world's cases occur (Xiao et al., 2014). Although the incidence of HFRS significantly declined during the 1990s, there has been an increasing trend since 2008 (Xiao et al., 2014; Zhang et al., 2014). The possible reasons for the emergence and re-emergence of these infectious diseases may be linked to climate change, population movement, rapid urbanization and increased surveillance efforts (Tong et al., 2015; Wu et al., 2016).

It is widely known that the global average combined land and ocean surface temperatures have increased by 0.85 °C over the period from 1880 to 2012 (Intergovernmental Panel on Climate Change, 2013). The Intergovernmental Panel on Climate Change (IPCC) indicates that the global average surface temperature will increase by 1.0–3.7 °C by 2081–2100 compared to 1986–2005, and other climatic variations, such as changes in rainfall patterns and relative humidity will also occur (Intergovernmental Panel on Climate Change, 2013). Climate change has, and will continue to, impact the transmission of vector and rodent-borne diseases by affecting the growth and development of the vectors or hosts, shortening the incubation period of the pathogens within the vectors, and impacting human behaviour (e.g. more time spent outdoors) (World Health Organization, 2012). The projected temperature increase and change in rainfall patterns may bring about an increase in cases of infectious diseases such as malaria, dengue and HFRS (Xiang et al., 2016; Zhang et al., 2010a; Zhou et al., 2010). In China, annual average land surface air temperature has increased by 0.5–0.8 °C over the past 100 years, and is projected to increase by 2.3–3.3 °C by 2050 as compared to 2000 (China National Development and Reform Commission, 2007). Extreme climate events, such as extremes in temperature, drought in north China, and flooding in south China, may become more frequent and intensive (China National Development and Reform Commission, 2007). The variations in temperature, rainfall, humidity and extreme events posed by climate change could facilitate infectious disease transmission and result in the possible increase in cases of infectious diseases in China (Tong et al., 2015).

In the Chinese health care system, both the clinical health sector and preventive medicine (public health system) play important roles in the protection of population health. In the clinical health system, hospitals provide patient diagnosis, treatment and management. In the public health system, the Centers for Disease Control and Prevention (CDC) work to protect and improve public health and safety, and focus on disease prevention, control and surveillance; and cases of notifiable diseases are reported by clinical professionals to the local CDC (He, 2005). Therefore, hospital clinical staff and CDC public health professionals perform different roles, and may have different views on infectious disease control and prevention. Given that the ability of the public health system (i.e. CDCs) to deal with emerging and re-emerging infectious diseases in the context of climate change has been extensively studied (Tong et al., 2017a; b; Tong et al., 2016), a similar investigation of the clinical health system where diseases are diagnosed and treated, is warranted. This study will contribute to a better understanding of infectious disease diagnosis, treatment, prevention and control in the face of climate change in China, and may also benefit disease control in other countries (Tong et al., 2016).

The study employs a cross-sectional questionnaire survey among clinical professionals to explore China's capacity of hospitals to deal with infectious diseases in the context of climate change. Further, the study explores participants' views on capacity building in the hospital sector to curb potential emerging and re-emerging infectious diseases due to climate change in China.

2. Methods

2.1. Questionnaire

A questionnaire was administered to clinical professionals in November 2015. The questionnaire instrument design was informed by previous studies and relevant literature on climate-sensitive diseases (National Development and Reform Commission of the PRC, 2015; Semenza et al., 2012; Tong et al., 2016; Wei et al., 2014). The questions asked about clinical professionals' thoughts on climate change, disease occurrence, the capacity of hospitals to deal with infectious diseases, and strategies to build the capacity of the hospital sector and curb the health impacts of climate change related to infectious diseases. An open-ended question was included to explore in greater depth, participants' understandings of disease control, diagnosis, treatment and management in the context of climate change. The questionnaire is included in Appendix A.

2.2. Study site and participants

The study site of Anhui Province was selected because it has a high incidence of infectious diseases, especially malaria and HFRS (Bi et al., 2005; Jiao et al., 2013; The People's Government of Anhui Province, 2015). Anhui Province is located in East China (see Fig. 1), and has a warm-temperate, semi-humid monsoonal climate with an average annual temperature between 14 and 17 °C, and annual precipitation between 800 and 1800 mm (The People's Government of Anhui Province, 2015).

Participants were clinical professionals from three major hospitals in Anhui. A total of 68 clinical professionals were surveyed in two general hospitals in the capital city of Anhui. A further 543 were surveyed in an infectious diseases hospital in a prefectural-level city. The clinical professionals included both doctors and nurses whose roles pertained to infectious disease diagnosis, treatment, and management.

2.3. Data collection

Investigators administered the questionnaire in the three hospitals. To maximize the response rate, the principal researchers selected six key senior contacts from hospitals to assist with the distribution of questionnaires to potential participants. The process of participation was voluntary, and no incentives were offered. There are 650 clinical professionals relating to infectious diseases in the three major hospitals, and for ease of administration, the entire population was used as sample. In total, 650 questionnaires were distributed, and after omitting incomplete questionnaires, 611 were analyzed, with a response rate of 94%.

2.4. Statistical analysis

All returned questionnaires were entered using EpiData 3.1 software (Lauritsen, 2008) to create a database. Statistical analyses were performed with Stata 13.1 (StataCorp, 2013). Participants' demographic characteristics were descriptively analyzed. Binary logistic regression was used to explore the association between binary responses and demographic variables. Ordinal logistic regression was used to explore the association between ordinal responses and demographic variables. The demographic variables were age, gender, professional level, length of employment, education, and occupation. The binary responses were "yes", and "no/unsure". The ordinal responses were "very concerned", "concerned", "slightly concerned", and "not concerned"; or "extremely important", "very important", "important", "less important" and "not important". Data were analyzed with a two-sided test and p-values less than 0.05 were considered statistically significant.



Fig. 1. Geographical location of study site - Anhui Province in China.

3. Results

3.1. Demographic information

Table 1 shows the demographics of the participants. In this study, 44% of the clinical professionals who participated were doctors, and 46.3% were nurses. While ages ranged from 20 to 70 years, 64.6% of professionals were aged below 30 years, with the mean age being 28.4 years. Of the participants, 70.1% were female. Junior level professionals accounted for 43.9%, intermediate level professionals 19.8% and senior level 4.6% of the total participants. Over 40% of the participants had worked in hospitals more than five years. More than 60%

Table 1
Demographic characteristics of the clinical professionals in Anhui, China (N = 611).

Demographic variables	Number ^a	Percent (%)
Age group (years)		
20-29	390	64.6
≥ 30	214	35.4
Gender		
Male	179	29.9
Female	419	70.1
Professional level		
Junior	268	43.9
Intermediate	121	19.8
Senior	28	4.6
Other ^b	194	31.7
Length of employment (years)		
< 5	322	56.2
5-9	107	18.7
≥ 10	144	25.1
Educational level		
Below undergraduate	239	39.5
Undergraduate degree or above	366	60.5
Occupation		
Doctor	269	44.0
Nurse	283	46.3
Other ^b	59	9.7

^a The total number may not be equal to 611 as some questions were not answered or classified.

^b Other professional level was those who had not been assessed in professional classification; other occupations included public health officer, lab technician and administrator.

held a university degree or higher qualifications, especially the doctors who were mostly highly educated with a bachelor of medicine degree or above (see [Supplementary Table S1 in Appendix B](#)).

3.2. Perceptions of climate change

As shown in [Table 2](#), more than 75% of the professionals were either very concerned or concerned about climate change. There was a statistically significant association between age group, professional level and the concern about climate change (see [Supplementary Table S2 in Appendix B](#)). Those who were over 30 years (OR = 1.993, 95% CI: 1.006–3.948, p = 0.048) and the senior staff (OR = 3.411, 95% CI: 1.372–8.482, p = 0.008) were more likely to be concerned about climate change. Furthermore, 71% of the professionals agreed with the statement that the weather was becoming warmer, especially nurses and the professionals who had been employed more than ten years (see [Supplementary Table S3 in Appendix B](#)).

Nearly all (95.6%) believed climate change would have an adverse influence on population health. Furthermore, 94.9% and 91.3% of professionals agreed that predicted increasing temperatures and changes in precipitation patterns would affect infectious disease transmission. Specifically, 83.8%, 74.3%, and 69.9% of professionals were either extremely or very likely to believe that there was an association between climate change and malaria, dengue, and HFRS, respectively.

3.3. Perceptions of infectious diseases

[Table 3](#) shows that about 20% of participants thought that there had been an increasing number of patients with malaria, dengue, and HFRS, and roughly 45% and 30% of professionals thought that climate change and population migration, respectively, were contributing factors. More than 81% of participants believed that malaria and HFRS hospital-reporting protocols were in place, and 75.8% believed so for dengue.

In terms of the diagnostic capability of hospital laboratories, 76.9% of professionals responded that their hospitals were ‘always’ or ‘mostly’ able to rapidly provide diagnostic tests for malaria, 67.3% for dengue, and 76.6% for HFRS, respectively. Some 84% of participants rated diagnostic and treatment capacity as excellent/good for malaria and HFRS, while 75% thought this was the case for dengue. Moreover, if an unusual cluster of cases was noticed, most professionals would take

Table 2

Perceptions of climate change and its impacts among clinical professionals in Anhui, China.^a

Opinions on climate change items	Number	Percent (%)
The concern of climate change		
Very concerned	124	20.4
Concerned	337	55.3
Slightly concerned	138	22.7
Not concerned	10	1.6
The area is becoming warmer		
Yes	434	71.0
No	84	13.8
Unsure	93	15.2
Climate change will have a negative effect on population health		
Yes	584	95.6
No	11	1.8
Unsure	16	2.6
Predicted increasing temperatures will influence the transmission of infectious diseases		
Yes	580	94.9
No	13	2.1
Unsure	18	3.0
Predicted changes in precipitation patterns will influence the transmission of infectious diseases		
Yes	558	91.3
No	24	3.9
Unsure	29	4.8
The association between climate change and malaria		
Extremely likely	242	39.6
Very likely	270	44.2
Somewhat likely	52	8.5
Not likely or Unsure	47	7.7
The association between climate change and dengue		
Extremely likely	192	31.4
Very likely	262	42.9
Somewhat likely	82	13.4
Not likely or Unsure	75	12.3
The association between climate change and HFRS		
Extremely likely	168	27.5
Very likely	259	42.4
Somewhat likely	110	18.0
Not likely or Unsure	74	12.1

^a Data in this table are frequency and percentage N (%).

actions such as discussing with colleagues and laboratory technicians, informing the public health officer, and consulting with the CDC. In addition, there were no significant differences in these perceptions of infectious diseases between doctors and nurses.

3.4. Perceptions of capacity building to deal with infectious disease risks

Clinical professionals' perceptions of the current capacity of their hospitals to deal with infectious diseases are shown in Table 4. Specifically, 95.3% of participants agreed that they had sufficient staff to deal with disease outbreaks. Also, more than 90% believed that their staff were well informed about current infectious disease trends, and that the quality of reported data from their hospitals to the CDC was excellent. However, 96.5% of professionals thought that logistical support in hospitals (for example administrative and maintenance services) needed to be strengthened. Overall, 94.2% either agreed strongly or somewhat that hospitals were well prepared for the threat of a serious emerging disease. There were no significant differences between perceptions of doctors and nurses regarding the current capacity of the hospital. Additionally, 95.5% agreed that more research on the health impacts of climate change was needed.

To build capacity to meet the challenge of emerging and re-emerging infectious diseases due to climate change, 75.9% of participants thought that prevention and control measures were extremely important strategies, and 73.7% believed more collaboration with their local CDC was extremely important (Table 5). Furthermore, multivariate ordinal logistic regression analysis showed that compared to those under 30 years, professionals aged over 30 years were more likely

Table 3

Perceptions of malaria, dengue and HFRS among clinical professionals in Anhui, China.^a

The trend of patients with these infectious diseases over the past 10 years				
	Increased N (%)	Decreased N (%)	Not a big change N (%)	Unsure N (%)
Malaria	137 (22.4%)	78 (12.8%)	171 (28.0%)	225 (36.8%)
Dengue	124 (20.3%)	86 (14.1%)	83 (13.6%)	318 (52.0%)
HFRS	138 (22.6%)	84 (13.7%)	150 (24.6%)	239 (39.1%)
The contributing factors if these infectious diseases have increased				
	Climate change N (%)	Urbanization N (%)	Population migration N (%)	Others N (%)
Malaria	290 (47.5%)	66 (10.8%)	195 (31.9%)	60 (9.8%)
Dengue	298 (48.8%)	89 (14.6%)	161 (26.3%)	63 (10.3%)
HFRS	270 (44.2%)	63 (10.3%)	180 (29.5%)	98 (16.0%)
The hospital has a protocol in place for the reporting of these notifiable diseases				
	Yes N (%)	No N (%)	Unsure N (%)	
Malaria	500 (81.8%)	22 (3.6%)	89 (14.6%)	
Dengue	463 (75.8%)	24 (3.9%)	124 (20.3%)	
HFRS	496 (81.2%)	29 (4.7%)	86 (14.1%)	
The hospital laboratory is able to rapidly provide diagnostic test results for these infectious diseases				
	Always N (%)	Mostly N (%)	Rarely N (%)	Unsure or sent to CDC for testing N (%)
Malaria	306 (50.1%)	164 (26.8%)	26 (4.3%)	115 (18.8%)
Dengue	207 (33.9%)	204 (33.4%)	23 (3.7%)	177 (29.0%)
HFRS	302 (49.4%)	166 (27.2%)	20 (3.3%)	123 (20.1%)
The infectious disease diagnostic ability of hospital				
	Excellent N (%)	Good N (%)	Fair N (%)	Poor N (%)
Malaria	232 (38.0%)	281 (46.0%)	83 (13.6%)	15 (2.4%)
Dengue	181 (29.6%)	274 (44.9%)	134 (21.9%)	22 (3.6%)
HFRS	274 (44.8%)	237 (38.8%)	82 (13.4%)	18 (3.0%)
The infectious disease treatment ability of hospital				
	Excellent N (%)	Good N (%)	Fair N (%)	Poor N (%)
Malaria	257 (42.1%)	257 (42.1%)	82 (13.4%)	15 (2.4%)
Dengue	214 (35.0%)	248 (40.6%)	129 (21.1%)	20 (3.3%)
HFRS	272 (44.5%)	248 (40.6%)	75 (12.3%)	16 (2.6%)
The actions if an unusual cluster of cases was noticed N (%)				
Discuss with colleagues				490 (80.2%)
Inform the public health officer at the hospital				528 (86.4%)
Discuss with laboratory technicians				443 (72.5%)
Consult the CDC				470 (76.9%)
Notify no one or other option				32 (5.2%)

^a Data in this table are frequency and percentage N (%). Abbreviation: HFRS, Hemorrhagic Fever with Renal Syndrome; CDC, Centers for Disease Control and Prevention.

to indicate that prevention and control measures are extremely important ($OR = 2.261$, 95% CI: 1.061–4.818, $p = 0.035$). Senior level staff were more likely to believe that more collaboration with the CDC was extremely important ($OR = 13.760$, 95% CI: 1.636–115.700, $p = 0.016$); while doctors were less likely to believe so (see Supplementary Table S4 in Appendix B). About 70% believed more funding was required for rural health care and that improving the accessibility of the online infectious disease reporting system for rural hospitals was also extremely important. More than 65% of those surveyed believed that the health impacts of emerging and re-emerging infectious diseases due to climate change could be addressed with strategies such as: better response mechanisms; strengthening the

Table 4Perceptions of hospital capacity to deal with infectious diseases in Anhui, China.^a

Questions concerning capacity to deal with infectious diseases	Agree strongly N (%)	Agree somewhat N (%)	Disagree somewhat N (%)	Disagree strongly N (%)	Unsure N (%)
Current numbers of staff at this hospital will be adequate in the event of major disease outbreaks	316 (52.4)	259 (42.9)	16 (2.7)	1 (0.2)	11 (1.8)
Staff are kept up to date and well informed about current infectious disease trends	252 (42.1)	300 (50.2)	27 (4.5)	3 (0.5)	16 (2.7)
The quality of reported data is excellent	277 (46.2)	291 (48.5)	17 (2.8)	1 (0.2)	14 (2.3)
Logistical support in this hospital needs to be strengthened	344 (57.2)	236 (39.3)	11 (1.8)	1 (0.2)	9 (1.5)
More research needs to be done on the health impacts of climate change	295 (49.3)	276 (46.2)	18 (3.0)	1 (0.2)	8 (1.3)
This hospital is well prepared to respond to the threat of a serious emerging disease	283 (47.0)	284 (47.2)	19 (3.2)	2 (0.3)	14 (2.3)

^a Data in this table are frequency and percentage N (%).

monitoring of infectious diseases; early warning systems; more health education programs; and increasing laboratory diagnostic ability in rural hospitals (Table 5). Moreover, improving environmental health, more health education, staff training and financial support were frequently reported in an open-ended question about improving vector/rodent-borne disease control, diagnosis, treatment and management in the context of climate change (see [Supplementary Table S5 in Appendix B](#)).

4. Discussion

Climate change poses a significant threat to global population health ([Intergovernmental Panel on Climate Change, 2014](#)). Clinical professionals are at the frontline of health care provision to the population and are likely to witness firsthand the health impacts of a changing climate ([Blashki et al., 2012](#)). They, therefore, provide a unique perspective on the health impacts of climate change and an in-depth understanding of local community health ([Blashki et al., 2012](#)). To the best of our knowledge, this study is the first of its kind to gauge clinical professionals' perceptions of the capacity of China's hospitals to manage infectious diseases under climate change and to provide insight for policymakers, practitioners and medical educators regarding climate change adaptation in the health sector.

Concern about climate change was acknowledged by most professionals, especially among senior staff and the group aged over 30 years. The majority of professionals, particularly nurses and those with longer terms of employment indicated that the weather was getting warmer. Nearly all respondents indicated climate change would adversely affect population health, and most indicated it would facilitate infectious disease transmission. Less than 10% of participants thought climate change was unlikely to be associated with malaria incidence compared to 12% for dengue and HFRS. The results were consistent with our

previous studies among CDC staff who indicated climate change was more likely to have an influence on malaria than HFRS, whilst the perception of an association between climate change and dengue was not as strong as in a previous study conducted in Guangdong ([Tong et al., 2016](#)). This is likely due to Guangdong having the highest incidence of dengue in China, whilst in Anhui there are fewer dengue cases reported ([Lai et al., 2015](#)). Moreover, compared with previous studies among CDC public health professionals in other provinces ([Tong et al., 2017a](#)), the hospital clinical professionals in this study were more likely to indicate that climate change would have an influence on HFRS. This could be due to the relatively high number of HFRS cases in Anhui Province, and hence firsthand knowledge of the disease and its determinants. Additionally, another study conducted among health experts in Europe also indicated their perceptions of the negative impact of climate change on vector-borne, food-borne, water-borne and rodent-borne diseases ([Semenza et al., 2012](#)). Despite 94.2% of participants agreeing strongly or somewhat that hospitals were currently well prepared for the threat of a serious emerging disease, climate change may present new challenges for health sectors such as increased incidence in certain climate-sensitive diseases, or diseases either not previously seen in the area, or not seen for some time. Such an influx in cases could stretch the coping capabilities of the present system. This may explain why the public health and clinical health sectors share concerns about potential emerging and re-emerging climate-sensitive diseases.

The majority of professionals indicated that climate change and population migration were considered as the most significant factors associated with the increase of these infectious diseases. This is in line with other studies that indicated the impact of climate change and migration would affect infectious disease transmission ([Gao et al., 2012; McMichael, 2015; Sang et al., 2015](#)). Higher temperatures and changing precipitation patterns can contribute to the increasing

Table 5Perceptions of strategies to build capacity to curb the health impact of climate change on infectious diseases in Anhui, China.^a

The importance of these strategies to curb the health impact of climate change on infectious diseases	Extremely important N (%)	Very important N (%)	Important N (%)	Less important N (%)	Not important N (%)
Prevention and control measures	458 (75.9)	138 (22.9)	6 (1.0)	1 (0.2)	0
Better response mechanisms when outbreaks occur	405 (67.4)	184 (30.6)	12 (2.0)	0	0
Strengthening the monitoring of infectious diseases	415 (68.8)	173 (28.7)	15 (2.5)	0	0
The ability to actively forecast disease outbreaks by early warning systems	406 (67.3)	174 (28.9)	22 (3.6)	1 (0.2)	0
More collaboration with CDC to deal with infectious disease outbreaks	443 (73.7)	143 (23.8)	15 (2.5)	0	0
More affordable access to health care for the population	362 (60.5)	206 (34.5)	29 (4.8)	1 (0.2)	0
More health education programs	398 (66.7)	180 (30.1)	18 (3.0)	1 (0.2)	0
Increase laboratory diagnostic ability in rural hospitals	391 (65.1)	189 (31.4)	21 (3.5)	0	0
Improve accessibility of online infectious disease reporting for rural hospitals	423 (70.5)	154 (25.7)	21 (3.5)	2 (0.3)	0
More funding for rural health care	425 (70.7)	156 (25.9)	19 (3.2)	1 (0.2)	0

^a Data in this table are frequency and percentage N (%). Abbreviation: CDC, Centers for Disease Control and Prevention.

population of vectors/rodents and more frequent contact with humans. Simultaneously, population movement can facilitate disease transmission from one region to another. In China, currently it is estimated that approximately 245 million people have migrated from poor rural areas to gain work in the cities (National Health and Family Planning Commission of the PRC, 2017). This “floating population” (highly mobile population) of internal migrants chiefly work in insecure low-wage jobs. Moreover, they often lack health insurance and defer seeking timely medical treatment, which could have a negative influence on infectious disease control (Qin et al., 2014). Future infectious disease control and prevention should be cognizant of climate change impacts and population movements on the transmission of these diseases. In addition, building a more comprehensive national health insurance system covering the internal migrant population's health expenses in any part of China may provide benefits for population health (Qin et al., 2014).

Most professionals claimed that there was a hospital protocol in place for the reporting of notifiable diseases and believed that the capacity for disease diagnosis and treatment was either excellent or good, especially for malaria and HFRS. As Anhui historically has a high incidence of malaria and HFRS (Chen and Qiu, 1993; Gao et al., 2012), professionals are more likely to have experience and confidence in dealing with these diseases, whereas historically there has been a low incidence of dengue in the Province. The majority of professionals believed that their hospital laboratories were able to provide rapid diagnostic test results for malaria, dengue and HFRS. Additionally, most professionals purported they would take comprehensive actions if they detected an unusual cluster of cases. This indicates there is a strong likelihood that outbreaks of emerging or re-emerging diseases would be detected early by the clinical professionals or the CDC. This detection of unusual trends could aid in curbing transmission if preventive measures are activated early.

Regarding the capacity of hospitals to deal with disease risks, most participants believed they were well prepared for the threat of a serious emerging disease. Of particular note, participants indicated there was a need to strengthen the hospital's logistical support. This is in line with another study conducted by Xu and Chu in 2010 focusing on logistics capacity in hospitals, which advocated that a reliable logistical support system is one of the most important components in modern health care systems and should be given higher priority to sustain and promote better health care services in the long-term (Xu and Chu, 2010). Currently, the main obstacles to improving hospitals' logistical support in China are the lack of high-quality staff and regulatory frameworks for logistics management within hospitals (Lin, 2012). Promoting specialized training for logistics staff and implementing management and quality control guidelines would be important.

Moreover, the problems in rural areas were highlighted, especially regarding the funding for rural health care support and accessibility to an online reporting system. The Severe Acute Respiratory Syndrome (SARS) outbreak demonstrated that rural health care was the weakest component of China's disease control and prevention system (Knobler et al., 2004). More resource allocation to rural areas would be a vital step in advancing China's capacity building in response to emerging infectious diseases due to climate change.

In this study, older and senior staff were more likely to indicate that primary prevention measures and interdisciplinary collaboration were important, compared with the younger or non-senior staff. Such differences could be due to the rich working experience of the groups, who may have a better understanding of the infectious disease control and prevention strategies. Most participants also suggested a need for improved environmental health, more health education programs and financial support to improve vector/rodent-borne disease control, diagnosis, treatment and management in the context of climate change. Some studies have made future predictions about the effect of climate variation on dengue and malaria (Caminade et al., 2014; Ebi and Nealon, 2016), although there are many confounding factors to

consider. Although some participants in this study indicated that changes have already been noted, it would be useful in future studies to gain an insight into stakeholders' perceptions of when global warming would reach a point where there is a marked effect on the burden of climate-sensitive diseases.

Some limitations of this study deserve mention. Firstly, this study was conducted in one province. The results may not be generalizable to clinical professionals in other provinces of China. Secondly, as dengue is an emerging and uncommon disease in Anhui, participants in this region may be less likely to have hands-on experience in dealing with dengue cases, and feel less confident about dengue diagnosis and treatment. Lastly, the study was conducted among three major hospitals in cities, and results may not be generalizable to rural areas, township-level hospitals or village-level clinics. Nevertheless, these findings may provide information for policymakers and clinical professionals pursuing initiatives to strengthen the capacity for hospitals to cope with a potential increase over time, in cases of climate-sensitive infectious diseases.

5. Conclusions

This study revealed that most clinical professionals thought climate change would have an impact on infectious diseases, and believed climate change and population migration were significant factors associated with infectious disease transmission. Health professionals in our study thought that the overall capacity of the hospital healthcare system to deal with infectious diseases was excellent. However, logistical support should be strengthened in hospitals and more climate change related research is needed. Issues that could be addressed include prevention and control measures, collaboration with the CDC, in-house staff training and improved healthcare systems in rural areas. The multiple direct and indirect impacts of climate change will continue to threaten the health of the Chinese population. These findings may help health policymakers develop organizational adaptation policies to address the adverse impact of climate change on health.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.socscimed.2018.04.021>.

References

Bi, P., Parton, K.A., Tong, S., 2005. El Nino-Southern oscillation and vector-borne diseases in Anhui, China. *Vector Borne Zoonotic Dis.* 5, 95–100.

Blashki, G., Abelsohn, A., Woollard, R., Arya, N., Parkes, M.W., Kendal, P., et al., 2012. General Practitioners' responses to global climate change - lessons from clinical experience and the clinical method. *Asia Pac. Fam. Med.* 11, 6.

Caminade, C., Kovats, S., Rocklöv, J., Tompkins, A.M., Morse, A.P., Colon-Gonzalez, F.J., et al., 2014. Impact of climate change on global malaria distribution. *Proc. Natl. Acad. Sci. U.S.A.* 111, 3286–3291.

Chen, H., Qiu, F., 1993. Epidemiologic surveillance on the hemorrhagic fever with renal syndrome in China. *Chin. Med. J. (Engl.)* 106, 857–863.

China National Development and Reform Commission, 2007. China's National Climate Change Programme. People's Republic of China: National Development and Reform Commission.

Ebi, K.L., Nealon, J., 2016. Dengue in a changing climate. *Environ. Res.* 151, 115–123.

Gao, H.W., Wang, L.P., Liang, S., Liu, Y.X., Tong, S.L., Wang, J.J., et al., 2012. Change in rainfall drives malaria re-emergence in Anhui Province, China. *PLoS One* 7, e43686.

Hansen, A., Cameron, S., Liu, Q., Sun, Y., Weinstein, P., Williams, C., et al., 2015. Transmission of haemorrhagic fever with renal syndrome in China and the role of climate factors: a review. *Int. J. Infect. Dis.* 33, 212–218.

He, Q., 2005. Bringing into full play the role of general hospitals in the prevention of contagious diseases. *Chin. J. Hosp. Adm.* 21, 31–33.

Hipgrave, D., 2011. Communicable disease control in China: from Mao to now. *J. Glob. Health* 1, 224–238.

Huang, X., Yin, H., Yan, L., Wang, X., Wang, S., 2012. Epidemiologic characteristics of haemorrhagic fever with renal syndrome in Mainland China from 2006 to 2010. *West. Pac. Surveill. Response* J. 3, 12–18.

Intergovernmental Panel on Climate Change, 2013. Climate Change 2013: the Physical Science Basis. Contribution of Working Group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability, Contribution of Working Group 2 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Jiao, Y., Fang, Q., Xie, M., Tao, Z., Wang, X., Xia, H., et al., 2013. Time and space distribution characteristics of malaria in Anhui province between 2006 and 2010. *J. Bengbu Med. Coll.* 38, 876–878.

Knobler, S., Mahmoud, A., Lemon, S., Mack, A., Sivitz, L., Oberholtzer, K., 2004. Learning from SARS: Preparing for the Next Disease Outbreak—workshop Summary. National Academies Press.

Lai, S., Huang, Z., Zhou, H., Anders, K.L., Perkins, T.A., Yin, W., et al., 2015. The changing epidemiology of dengue in China, 1990–2014: a descriptive analysis of 25 years of nationwide surveillance data. *BMC Med.* 13, 100.

Lauritsen, J.M., 2008. EpiData Classic, Data Management and Basic Statistical Analysis System. Odense Denmark. EpiData Association. [Http://www.epidata.dk](http://www.epidata.dk).

Lin, Z., 2012. Reality barrier of synergy in Chinese hospital logistics service. *Chin. Hosp. Manag.* 32, 77–78.

McMichael, C., 2015. Climate change-related migration and infectious disease. *Virulence* 6, 548–553.

National Development and Reform Commission of the PRC, 2015. China's Policies and Actions on Climate Change (2015).

National Health and Family Planning Commission of the PRC, 2016. 2016 China Health Statistical Yearbook. Peking Union Medical College Press, Beijing.

National Health and Family Planning Commission of the PRC, 2017. Report on China's Migrant Population Development. pp. 2017.

Qin, X., Pan, J., Liu, G.G., 2014. Does participating in health insurance benefit the migrant workers in China? An empirical investigation. *China Econ. Rev.* 30, 263–278.

Sang, S., Chen, B., Wu, H., Yang, Z., Di, B., Wang, L., et al., 2015. Dengue is still an imported disease in China: a case study in Guangzhou. *Infect. Genet. Evol.* 32, 178–190.

Semenza, J.C., Suk, J.E., Estevez, V., Ebi, K.L., Lindgren, E., 2012. Mapping climate change vulnerabilities to infectious diseases in Europe. *Environ. Health Perspect.* 120, 385–392.

StataCorp, 2013. Stata Statistical Software: Release 13. StataCorp LP, College Station, TX.

The People's Government of Anhui Province, 2015. Geology & climate [online]. Available. <http://english.ah.gov.cn/content/channel/53e466319a05c28a77deb28e/>, Accessed date: 7 October 2015.

Tong, M.X., Hansen, A., Hanson-Easey, S., Cameron, S., Xiang, J., Liu, Q., et al., 2017a. Health professionals' perceptions of hemorrhagic fever with renal syndrome and climate change in China. *Global Planet. Change* 152, 12–18.

Tong, M.X., Hansen, A., Hanson-Easey, S., Cameron, S., Xiang, J., Liu, Q., et al., 2017b. Perceptions of malaria control and prevention in an era of climate change: a cross-sectional survey among CDC staff in China. *Malar. J.* 16, 136.

Tong, M.X., Hansen, A., Hanson-Easey, S., Cameron, S., Xiang, J., Liu, Q., et al., 2015. Infectious diseases, urbanization and climate change: challenges in future China. *Int. J. Environ. Res. Publ. Health* 12, 11025–11036.

Tong, M.X., Hansen, A., Hanson-Easey, S., Xiang, J., Cameron, S., Liu, Q., et al., 2016. Perceptions of capacity for infectious disease control and prevention to meet the challenges of dengue fever in the face of climate change: a survey among CDC staff in Guangdong Province, China. *Environ. Res.* 148, 295–302.

Wei, J., Hansen, A., Zhang, Y., Li, H., Liu, Q., Sun, Y., et al., 2014. The impact of climate change on infectious disease transmission: perceptions of CDC health professionals in Shanxi Province, China. *PLoS One* 9 e109476.

World Health Organization, 2012. Strengthen Control of Vectorborne Diseases to Lessen the Impact of Climate Change in Western Pacific Region with Focus on Cambodia, Mongolia and Papua New Guinea: Final Project Report. WHO Regional Office for the Western Pacific, Manila.

Wu, X., Lu, Y., Zhou, S., Chen, L., Xu, B., 2016. Impact of climate change on human infectious diseases: empirical evidence and human adaptation. *Environ. Int.* 86, 14–23.

Xiang, J., Hansen, A., Liu, Q., Liu, X., Tong, M.X., Sun, Y., et al., 2016. Association between dengue fever incidence and meteorological factors in Guangzhou, China, 2005–2014. *Environ. Res.* 153, 17–26.

Xiao, H., Tian, H.Y., Gao, L.D., Liu, H.N., Duan, L.S., Basta, N., et al., 2014. Animal reservoir, natural and socioeconomic variations and the transmission of hemorrhagic fever with renal syndrome in Chenzhou, China, 2006–2010. *PLoS Neglected Trop. Dis.* 8, e2615.

Xu, Y., Chu, F., 2010. Adhere to scientific development to improve the overall logistics capacity in hospital. *Chin. Health Qual. Manag.* 17, 108–110.

Yin, J.H., Zhou, S.S., Xia, Z.G., Wang, R.B., Qian, Y.J., Yang, W.Z., et al., 2014. Historical patterns of malaria transmission in China. *Adv. Parasitol.* 86, 1–19.

Zhang, W., Guo, W.D., Fang, L.Q., Li, C.P., Bi, P., Glass, G.E., et al., 2010a. Climate variability and hemorrhagic fever with renal syndrome transmission in Northeastern China. *Environ. Health Perspect.* 118, 915–920.

Zhang, W.Y., Wang, L.Y., Liu, Y.X., Yin, W.W., Hu, W.B., Magalhaes, R.J., et al., 2014. Spatiotemporal transmission dynamics of hemorrhagic fever with renal syndrome in China, 2005–2012. *PLoS Neglected Trop. Dis.* 8, e3344.

Zhang, Y., Bi, P., Hiller, J.E., 2010b. Meteorological variables and malaria in a Chinese temperate city: a twenty-year time-series data analysis. *Environ. Int.* 36, 439–445.

Zhou, S., Wang, Y., Tang, L., 2007. Malaria situation in the People's republic of China in 2006. *Chin. J. Parasitol. Parasit. Dis.* 25, 439–441.

Zhou, S.S., Huang, F., Wang, J.J., Zhang, S.S., Su, Y.P., Tang, L.H., 2010. Geographical, meteorological and vectorial factors related to malaria re-emergence in Huang-Huai River of central China. *Malar. J.* 9, 337.